Product User Manual

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Model GA3105
6-Port Reflectometer

Document # 930003, Rev. 1

April, 1999

GAE GERLING APPLIED ENGINEERING, INC.
P.O. Box 580816 ♦ Modesto, CA 95358
www.2450mhz.com

REVISION HISTORY			
REV.	**DESCRIPTION**	**DATE**	**APPROVAL**
1	PROTOTYPE RELEASE	21APR99	JFG

WARRANTY

Products manufactured and sold by Gerling Applied Engineering, Inc. (“GAE”) are warranted to be free of defects in materials and workmanship under normal use and service for a period of twelve (12) months from the date of original shipment. GAE’s obligation under this warranty is limited to repairing or replacing, at GAE’s option, all non-consumable component parts. Consumable parts are specifically excluded from this warranty and may include, but are not be limited to, magnetrons, fuses, lamps, seals, o-rings, v-belts, and fluids. All warranty repairs are to be done at GAE’s facility or as otherwise authorized by GAE. All shipping charges for warranty repair or replacement are the purchaser’s responsibility unless otherwise agreed to by GAE.

This warranty supercedes all other warranties, expressed or implied. No warranty is given covering the product for any particular purpose other than as covered by the applicable product specifications. GAE assumes no liability in any event for incidental or consequential damages, financial losses, penalties or other losses incurred in conjunction with the use of GAE products.

DOCUMENT CONVENTIONS

NOTE: *Means the reader should take note. Notes contain helpful information, suggestions, or references to other sections, chapters, or documents.*

CAUTION: *Means the reader should be careful. You are doing something that might result in equipment damage or loss of data.*

WARNING: *Means danger. A situation exists that could cause bodily injury or death. All personnel must be aware of the hazards involved with high voltage electrical circuitry and high power microwave devices.*

WARNING

The GA3105 is intended for use with other equipment capable of producing a microwave field that is potentially hazardous to operating personnel. It must never be connected or operated in a manner that allows a field in excess of 10 milliwatts per square centimeter to be generated in an area accessible to operating personnel. Contact GAE, Inc. for technical support prior to installation and/or operation of this unit if there is any question or concern about microwave leakage.

All waveguide flange and electrical cable connections must be secure prior to operation of the GA3105. Never operate the microwave generator without a properly rated absorbing load attached. To ensure safe operation and prevent microwave leakage, the equipment must be periodically inspected and maintained as required or recommended.

TABLE OF CONTENTS

ATTACHMENTS:

Document Type	Number	Title
Drawing	910197	Assembly and Outline Drawing
Drawing	910225	Typical Setup Configuration

EQUIPMENT DESCRIPTION

The model GA3105 6-Port Reflectometer is designed for use in high power microwave networks as a device to facilitate the matching of difficult load impedances. Simple directional power monitors that are typically used with stub tuners for load matching purposes provide only a measure of power level in the waveguide. However, the GA3105, when used with a suitable display (as described later in this manual), can provide detailed information about the phase and amplitude of a reflection, thereby allowing the operator to achieve the best possible impedance match more quickly.

The GA3105 is also useful for observing the dynamics of a load impedance during high power heating. Load impedances can change dramatically during the heating process, examples of which include those encountered in plasma processing (before and after ignition), ceramics sintering and polymer curing.

The GA3105 is a phase sensitive detector that is inserted in the waveguide between the microwave generator and impedance matching device (such as a stub tuner). Non-directional sensors measure the voltage in the waveguide at four points having a precise phase relationship. Using an oscilloscope with +X, -X, +Y and -Y inputs, the signals from these sensors can be used to generate a polar display in a format identical to that of a Smith Chart.

Specifications

Waveguide	WR284
Flange	UG-584/U (round) with taper for quick-release clamp
Frequency	2450 MHz nominal
Sensor Output	Non-linear voltage from crystal detector
Coupling Factor	60 dB factory setting (user adjustable)
Overall Length	12.50 inches (31.8 cm) flange-to-flange
Net Weight	4.2 lb. (9.2 kgm)

INSTALLATION

Preliminary Inspection

Upon arrival at the installation site the GA3105 should be thoroughly inspected for damage or wear caused during shipping. Any visible damage to the packaging material or GA3105 should be noted and reported immediately to the shipping company in accordance with standard claims procedures.

Waveguide Configuration

Refer to drawing 910225 for a typical setup configuration in a microwave network. The GA3105 must be installed between the source of microwave power and the impedance matching device (tuner). If an isolator is used with the microwave generator then the GA3105 must be between the isolator and tuner. For best performance the GA3105 should be located as close as possible to the tuner. Similarly, the tuner should be located as close as possible to the load being matched to help avoid a resonant condition between the tuner and the input to the load cavity.

Ambient Conditions

The crystal detectors used with the GA3105 have a high temperature coefficient (as do all similar devices). Because of this, the calibration may drift in the event of large variations in ambient temperature. It is important to use the GA3105 in an area where ambient conditions (especially temperature) remain stable.

Oscilloscope Display

For best results the oscilloscope used with the GA3105 should have the following characteristics:

- XY operation
- Independent (+) and (–) signal amplifiers for both X and Y channels, each with the following capabilities:
  - gain control
  - short circuiting
  - DC signal amplification
- Minimum drift
- 5 mV per division gain (both channels)
- Z-axis pulsing (for use with high ripple microwave generators)

Again, refer to drawing 910225 for information on connecting the oscilloscope to the GA3105.

Microwave Generator

The GA3105 provides optimal performance when used with a microwave generator having very low ripple in the output waveform. Any ripple in the waveform results in a broadening of the spot on the oscilloscope display. Refer to the discussion under “Pulsed Waveform Operation” in the next section for information on using the GA3105 with a high ripple microwave generator.

Flange Connections

The waveguide flanges at both ends of the GA3105 must be properly connected to another waveguide component. They are designed to be used with the GA8401 Quick-Release clamp when connected to another similarly designed flange. They can also be connected to any other standard WR284 round flange (UG-584/U) using suitable fastener hardware.

Flange Alignment Pins

Each flange connection that uses a quick-release clamp requires two alignment pins for proper alignment of the adjacent waveguide sections. All GAE waveguide components include one alignment pin for each flange designed for use with quick-release clamps. Alignment pins can be installed into either of two threaded holes centered above and below the waveguide broadwalls. For obvious reasons, the pins must not be installed such that they are opposite each other on mating flanges.

Microwave Leakage – Regulatory limits for microwave leakage relate to standards for human safety and interference with other electronic devices. Standards for human safety as adopted by OSHA, the International Electrotechnical Commission (IEC) and other regulatory agencies limit leakage to 5 mW/cm^2 measured at 5 cm from the leakage source under normal operating conditions, and 10 mW/cm^2 at 5 cm from the source under abnormal operating conditions. The U.S. Federal Communications Commission (FCC) has established regulations limiting the emission of energy at frequencies outside the ISM bands. The GA3105 meets these requirements when connected to a suitable waveguide load.

SETUP AND OPERATION

Initial Calibration

The following procedure calibrates the GA3105 for use with an oscilloscope having characteristics as described in the previous section. In addition, the deflection measurements given in the procedure below assume the display is 10 cm wide and 8 cm high. If the display used is a different overall size then the deflections given below must be corrected accordingly.

1. Set up the GA3105 as shown in drawing 910225, except leave out the tuner and load.
2. Connect a high return loss (low reflection) dummy load to the output end of the GA3105.
3. Turn on the microwave generator and set the output power level to the maximum power that will be used during normal operation.
4. Short out all of the input signal amplifiers on the oscilloscope and carefully center the spot on the oscilloscope display.
5. Set the gain on all signal amplifiers to full.
6. Remove the short for the +Y amplifier. Note that the spot has moved downward (this is due to the negative polarity of the crystal detectors).

CAUTION: *The following step can result in equipment damage if not performed carefully.*

7. Grasp the +Y detector probe on the GA3105 and carefully loosen the screw on the side of the probe mounting block. Slowly move the probe up or down until the spot on the display has a 2 cm downward deflection. Tighten the mounting block screw.
   NOTE: A small set screw next to the probe connector may prevent the probe from being moved downward sufficiently. Adjust this set screw as necessary to allow sufficient downward movement of the probe.
8. Repeat steps 6 and 7 for each of the other detector probes, making sure that the respective signal amplifiers for all other probes are shorted out.
9. With all other amplifiers shorted out, remove the short on one amplifier and adjust its gain until the spot is at 1.2 cm deflection.
10. Repeat step 9 for all other amplifiers.

11. Turn on all amplifiers. The spot should now be centered and represents the correct display for a matched load.

12. Turn off the microwave generator, remove the dummy load and attach a short circuit plate to the output end of the GA3105.

13. Turn on the microwave generator and adjust the output power level to full. The spot on the display should now be at a 4 cm deflection at the 3 o'clock position.

The GA3105 is now ready for operation. Using a sliding short circuit in place of the fixed short circuit plate, the spot will move in a circle around the center of the display at a constant radius as the sliding short circuit is adjusted. The spot will move CCW around the center as the shorting plate is moved towards the generator.

Operation with Pulsed Waveform

As discussed in the previous section, the spot on the display will broaden when the GA3105 is used with a generator having a pulsed output waveform. The frequency modulation caused by the waveform ripple broadens the spot in an angular dimension while amplitude variations in the ripple cause radial broadening. With a pulsed waveform from a microwave generator having a half-wave or full-wave rectified power supply, the spot will always go through the center of the display regardless of the reflection being measured, and the angular broadening can be 90 degrees or more.

To minimize this effect, the Z-axis of the oscilloscope should be pulsed so that the trace beam is on for only a short period of time during the peaks of the microwave generator waveform pulse (see Figure 1). This prevents the spot from tracing the pattern caused by amplitude and frequency modulations between the waveform peaks.

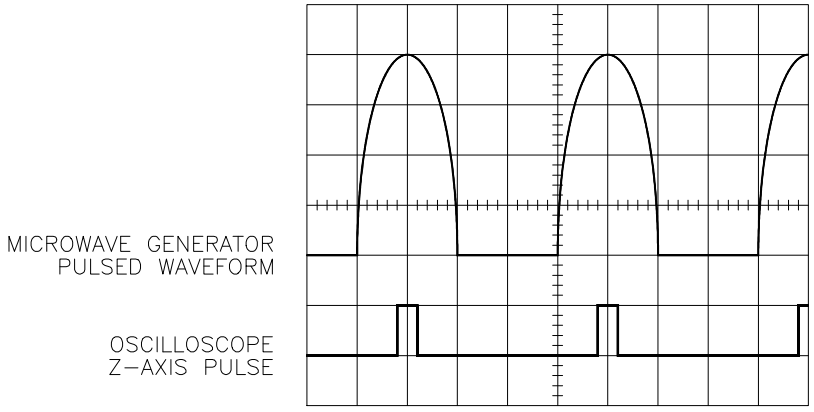
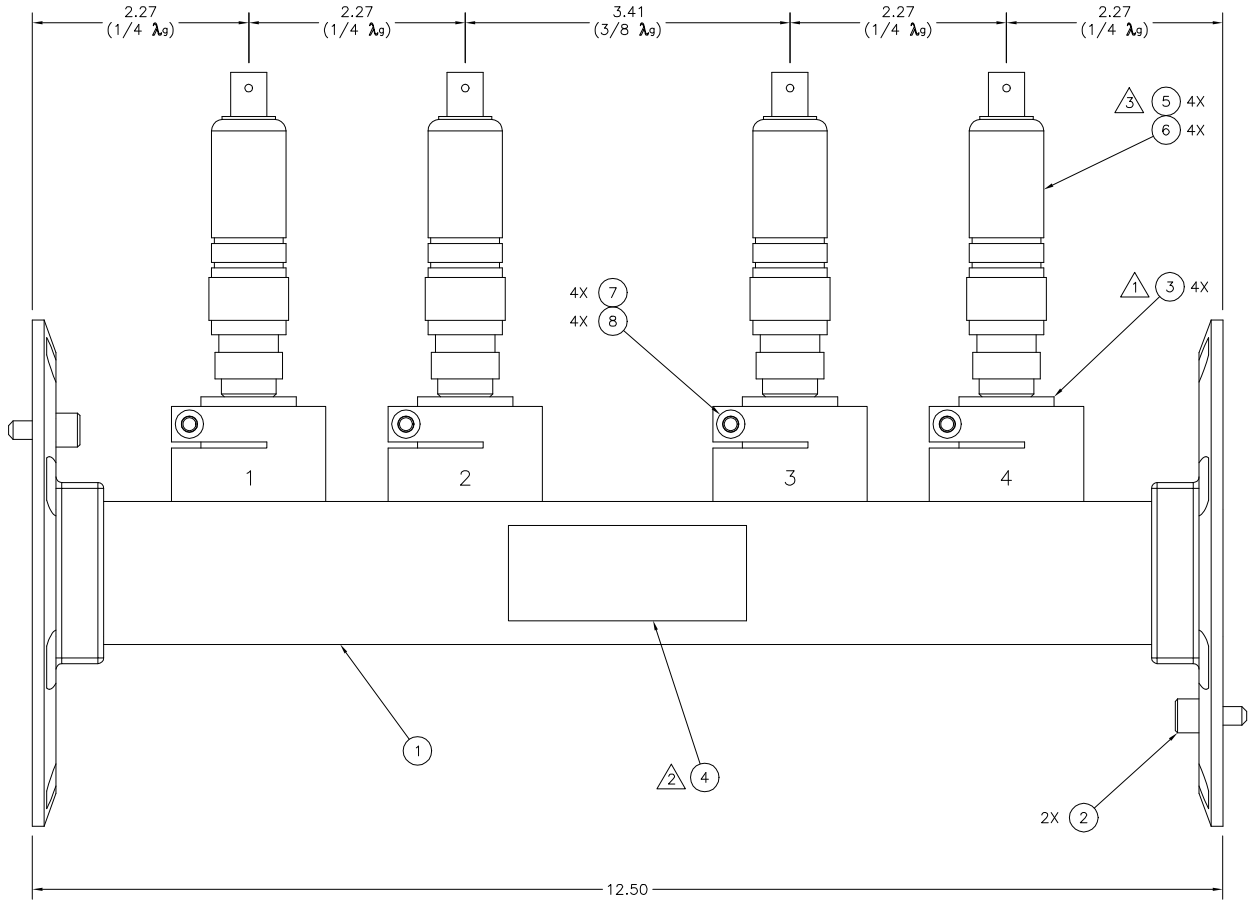
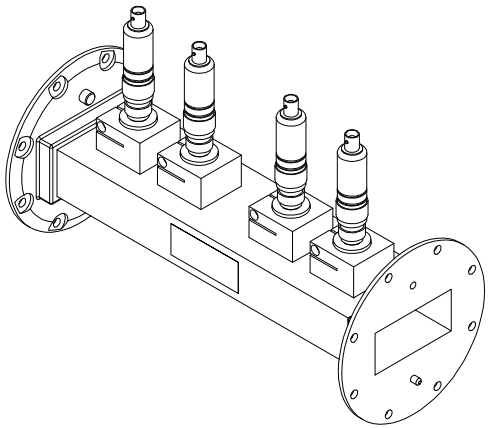


Figure 1 – Waveforms from pulsed microwave generator and oscilloscope z-axis pulsing.

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	2	ITEM 7 WAS #8–32	01MAR00	JFG





NOTES: (UNLESS OTHERWISE SPECIFIED)

1. CALIBRATE PROBE (ITEM 3) FOR 60 dB COUPLING FACTOR WITH FLAT LOAD (NO VSWR).
2. PRODUCT ID LABEL (ITEM 4) TO HAVE THE FOLLOWING DATA: 6–PORT REFLECTOMETER
   MODEL/PART NO.: GA3105
   SERIAL NO.: <DATE CODE S/N>
3. DETECTOR ID LABEL (ITEM 5) TO HAVE SERIAL NUMBER DATA FORMATTED AS "GA3105–XXX–Y" WHERE "XXX" IS LAST THREE DIGITS OF PRODUCT SERIAL NUMBER AND "Y" IS PROBE POSITION.

ITEM	QTY REQD	REF DES	PART OR IDENTIFYING NO.	DESCRIPTION
9	1		920005	FINAL TEST DATA SHEET
8	4		722021	LOCKWASHER, SPLIT–RING, #6, SST
7	4		704201–16	SHCS, #6–32 X 1.00, SST
6	4		040101	CRYSTAL DETECTOR, 50 OHM, TYPE N MALE TO BNC
5	4		910200	LABEL, CRYSTAL DETECTOR ID
4	1		910199	LABEL, PRODUCT ID
3	4		910198	FIELD PROBE ASSY
2	2		910171	PIN, FLANGE ALIGNMENT
1	1		910196	WAVEGUIDE DIP BRAZE ASSY

BILL OF MATERIALS

N/A	GA3105
NEXT ASSY	USED ON
APPLICATION	

THIRD ANGLE PROJECTION

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES (MM)
TOLERANCES
DECIMALS .XX ± .02 .XXX ± .010
ANGLES ± 1/2 DEG

DO NOT SCALE DRAWING

MATERIAL: SEE BOM

FINISH: N/A

CONTRACT NO.

APPROVAL	DATE
DRAWN JFG	20MAR99
CHECKED	
ENGR	

GAE GERLING APPLIED ENGINEERING, INC.
P.O. BOX 580816, MODESTO, CA 95358

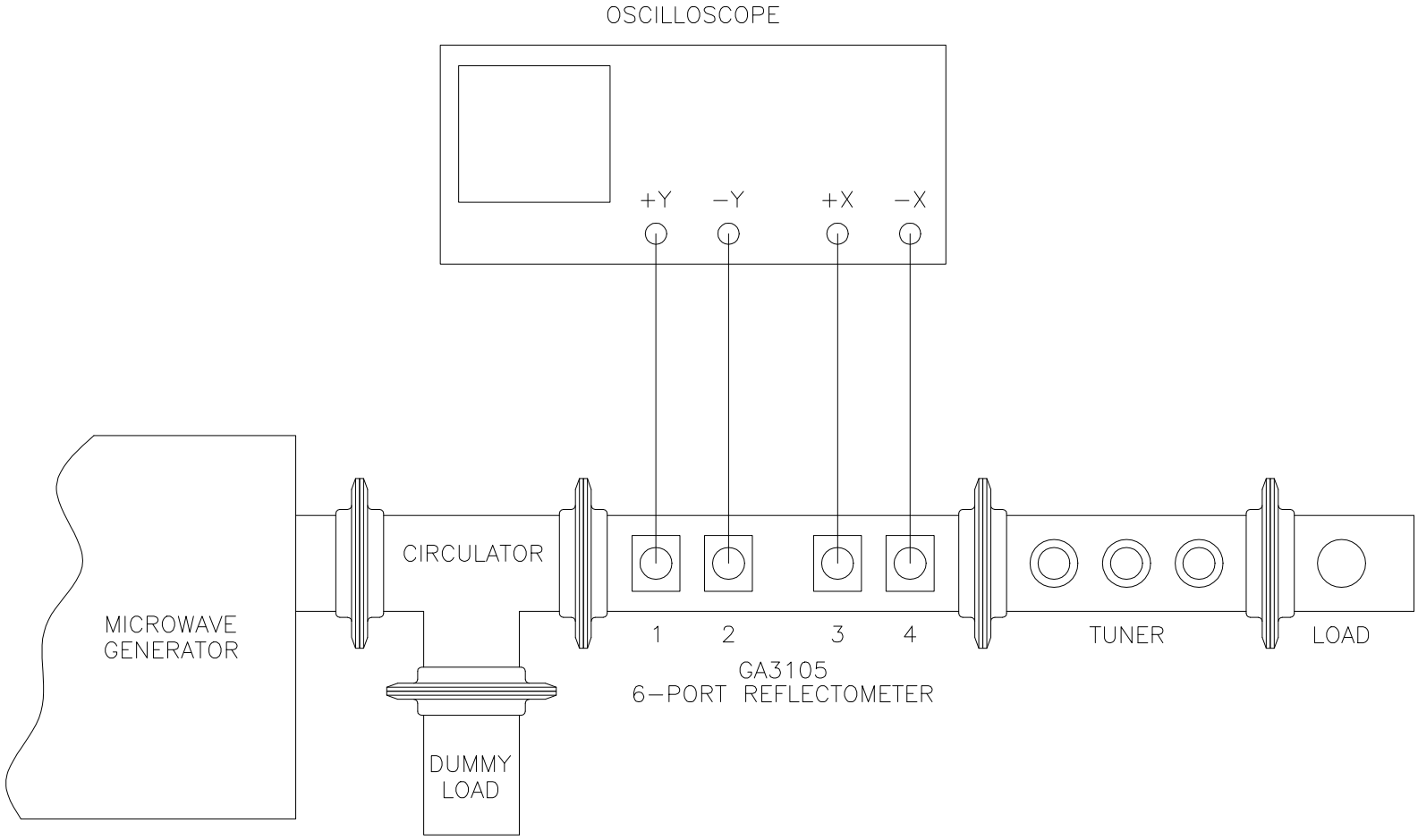
6–PORT REFLECTOMETER
FINAL ASSEMBLY

SIZE	DWG. NO.	REV
C	910197	2

SCALE NONE SHEET 1 OF 1

DWG NO. 910197 SH 1 REV 2

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	1	PROTOTYPE RELEASE	29APR99	JFG



DWG NO. 910225 SH 1 REV 1

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES (MM) TOLERANCES DECIMALS .XX ±.02 .XXX± .010 ANGLES ± 1/2 DEG	CONTRACT NO.
DO NOT SCALE DRAWING	APPROVAL / DATE; DRAWN JFG 29APR99; CHECKED; ENGR
MATERIAL	THIS DOCUMENT SHALL NOT BE REPRODUCED, NOR SHALL THE INFORMATION CONTAINED HEREIN BE USED BY OR DISCLOSED TO OTHERS EXCEPT AS EXPRESSLY AUTHORIZED IN WRITING BY GAE, INC.
FINISH	
NEXT ASSY: GA3105	USED ON
APPLICATION	

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TYPICAL SETUP CONFIGURATION, 6−PORT REFLECTOMETER

SIZE	DWG. NO.	REV
C	910225	1

SCALE NONE SHEET 1 OF 1